MATIERAL SPECIFICATION FOR PRECAST CONCRETE - MATERIALS AND PRODUCTION

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1355.01 SCOPE

This specification covers the requirements for materials, production, methods for testing, acceptance, referee testing, payment reductions, delivery and storage of precast concrete.

Additional requirements for precast concrete elements shall be as specified elsewhere in the Contract Documents.

1355.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 363	Repairing Concrete Pavement and Concrete Base with Precast Concrete Slabs
OPSS 904	Concrete Structures
OPSS 905	Steel Reinforcement for Concrete
OPSS 906	Structural Steel for Bridges
OPSS 909	Prestressed Concrete - Precast Girders
OPSS 910	Stressing Systems for Post Tensioning
OPSS 912	Precast Concrete Culverts with Spans Greater Than 3.0 m

OPSS 916 Precast Concrete Bridge Elements
OPSS 919 Formwork and Falsework
OPSS 928 Structure Rehabilitation - Concrete Removals
OPSS 929 Abrasive Blast Cleaning - Concrete Construction
OPSS 930 Structure Rehabilitation - Concrete Patches, Refacing, and Overlays
OPSS 932 Crack Repair - Concrete
OPSS 941 Mechanically Stabilized Earth Systems
OPSS 950 Glass Fibre Reinforced Polymer (GFRP) Reinforcement for Concrete

Ontario Provincial Standard Specifications, Material

OPSS 1002 Aggregates - Concrete
OPSS 1213 Hot Applied Rubberized Asphalt Waterproofing Membrane
OPSS 1302 Water
OPSS 1306 Burlap
OPSS 1350 Concrete - Materials and Production
OPSS 1440 Steel Reinforcement for Concrete
OPSS 1640 Glass Fibre Reinforced Polymer (GFRP) Reinforcement for Concrete

Ministry of Transportation, Ontario Publications

Designated Sources for Materials (DSM)

MTO Laboratory Testing Manual:
LS-100 Method for Rounding Off of Test Data and Other Numbers
LS-407 Method of Test for Compressive Strength of Moulded Cylinders
LS-410 Method of Test for Compressive Strength of Concrete Cores
LS-412 Method of Test for Scaling Resistance of Concrete Surfaces Exposed to Deicing Salts
LS-426 Method of Test for Compressive Strength of High Strength Concrete Cylinders
LS-432 Method of Test for Microscopical Determination of Air Void System Parameters in Hardened Concrete
LS-433 Method of Test for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

MTO Forms:
PH-CC-117 Concrete Temperature Record
PH-CC-322 Concrete Construction Report
PH-CC-340 Field Sample Data Sheet - Concrete Section
PH-CC-433A Concrete Mix Design Form A
PH-CC-701 Request to Proceed
PH-CC-702 Notice to Proceed
PH-CC-821 Manufacturer's Certificate of Conformance

Canadian Standards Association (CSA)

A23.2-3C Making and Curing Concrete Compression and Flexural Test Specimens*
A23.2-14C Obtaining and Testing Drilled Cores for Compressive Strength Testing*
A23.2-1D Moulds for Forming Concrete Test Cylinders Vertically*
A23.4-16 (R2021) Precast Concrete Materials and Construction
G189 Sprayed Metal Coatings for Atmospheric Corrosion Protection
W47.1:19 Certification of Companies for Fusion Welding of Steel
W59-18(R2023) Welded Steel Construction
A3001 Cementitious Materials for Use in Concrete**

* [Part of A23.1-24/A23.2-24 - Concrete Materials and Methods of Concrete Construction/Methods of Test and Standard Practices for Concrete]
** [Part of A3000:23 - Cementitious Materials Compendium]

ASTM International

A153/A153M-23	Zinc Coating (Hot-Dip) on Iron and Steel Hardware
B633-23	Electrodeposited Coatings of Zinc on Iron and Steel
C171-20	Sheet Materials for Curing Concrete
C403/C403M-23	Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance

1355.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Bridge Elements means as defined in OPSS 916.

Bughole means a small regular or irregular cavity resulting from entrapment of air bubbles in the surface of formed concrete during placement and consolidation.

Cold Joint means the interface surface other than at a formed joint that occurs when plastic concrete is placed against concrete that has taken its initial set.

Cold Weather means those conditions when the ambient air temperature is at or below 5°C. It is also considered to exist when the ambient air temperature is at or is likely to fall below 5°C within 96 hours after completion of concrete placement. Ambient air temperature refers to shade temperature.

Concrete Appurtenances means as defined in OPSS 912.

Concrete Barrier means as defined in OPSS 740 except it refers to permanent precast concrete barrier only.

Culvert means as defined in OPSS 912.

Dry Cast Concrete means concrete of near-zero slump at the time of placing, that is consolidated in the form using low-frequency high-amplitude vibration.

Element means an individual precast concrete unit.

Element Type means an element defined by function and cross-sectional shape.

Girder means as defined in OPSS 909.

Girder Type means a girder differentiated by its cross-section shape such as box girder type (solid or voided), I-girder type [such as Nebraska University (NU) and Canadian Precast Prestressed Concrete Institute (CPCI)], or T-girder type.

Honeycombing means a rough and stony concrete surface with voids where the mortar did not fill the spaces between the coarse aggregates.

Indoor Precast Concrete Plant means a building, which is a permanent structure, providing protection from sun, wind, and rain and which is temperature controlled, such that the temperature does not fall below 15°C or exceed 30°C.

Mechanically Stabilized Earth System (MSE) means as defined in OPSS 941.

Noise Barrier means the precast concrete components of noise barrier systems including the bottom panel and the upper reflective panel as defined in OPSS 760.

Post-Tensioning means as defined in OPSS 910.

Pour Line means a visible delineation between two placements of concrete where the concrete from each placement is well-bonded to the other.

Prestressed Concrete means reinforced concrete in which internal stresses have been initially introduced so that subsequent stresses resulting from dead load and superimposed loads are counteracted to a desired degree. This may be accomplished by pretensioning or post-tensioning.

Pretensioning means a method of prestressing in which strands are tensioned before the concrete is placed.

Reinforcing Steel Bars means carbon steel reinforcing bars and/or stainless steel reinforcing bars.

Reinforcing Bars means reinforcing steel bars, or glass fibre reinforced polymer (GFRP) reinforcing bars.

Segregation means visible separation of the mortar and coarse aggregate particles in the concrete, resulting in concrete that is not uniform in appearance or proportions.

Slabs means as defined in OPSS 363.

Steel Reinforcement means as defined in OPSS 905.

Strand means as defined in OPSS 905.

Structure means any bridge, culvert, tunnel, retaining wall, wharf, dock, or guideway, or any part thereof, or other reinforced concrete component designed to carry loads, including high mast pole footings and sign support footings.

Sweep means the lateral deviation from straightness of an element with respect to its design centre line.

Tendon means as defined in OPSS 910.

Wet Cast Concrete means concrete with a measurable slump at the time of placing, that is consolidated by vibration.

1355.04 DESIGN AND SUBMISSION REQUIREMENTS

1355.04.01 Design Requirements

1355.04.01.01 Precast Concrete Elements

The design shall be as specified in the Contract Documents.

1355.04.01.02 Concrete Mix Design

The design requirements for the concrete mix design shall be according to the Concrete Mix Design subsection of OPSS 1350.

1355.04.02 Submission Requirements

1355.04.02.01 Mix Design

The concrete mix design shall be submitted according to the Mix Design clause of OPSS 1350.

1355.04.02.02 Certification of Precast Plant

The precast plant certificate verifying that the plant is certified as specified in the Precast Plant Certification subsection shall be submitted with the concrete mix design submission.

For multi-year Contracts, documentation verifying that the precast plant, continues to hold valid certification shall be submitted annually, for all plants supplying the work.

Copies of the precast plant certification audit reports of the Canadian Precast Concrete Quality Assurance Program (CPCQA), Canadian Standards Association (CSA), or both as applicable, and related documentation, shall be submitted to the Owner upon request.

1355.04.02.03 Certification of Ready Mixed Concrete Production Facilities

Submission of ready-mixed concrete production certification shall be according to OPSS 1350, when concrete is supplied by a ready-mix concrete plant.

1355.04.02.04 Temperature Control Plan

A description of the method for monitoring and effectively controlling the temperature of the concrete during the curing and protection period shall be submitted to the Contract Administrator 7 Days prior to the commencement of fabricating the elements.

1355.04.02.05 Notification of Placement

The Contract Administrator shall be notified in writing at least 14 Days prior to commencement of fabrication and the fabrication schedule shall be submitted. Any changes in the fabrication schedule shall be provided to the Contract Administrator in writing.

1355.04.02.06 Welding

When resistance welding is planned for fabricating steel reinforcement cages, a proposal shall be submitted to Contract Administrator for Owner's approval a minimum of 14 Days prior to fabrication.

Submissions for welding shall be according to OPSS 905.

1355.05 MATERIALS

1355.05.01 Admixtures for Concrete

Admixtures for concrete shall be according to OPSS 1350.

1355.05.02 Aggregates

1355.05.02.01 General

Aggregates shall be according to OPSS 1002.

1355.05.02.02 Limestone Filler

Limestone filler shall be according to the following:

a) Requirements specified in OPSS 1002 with the exception that use of limestone filler is not confined to self-consolidating concrete (SCC).

b) Requirements specified in CSA A23.1, Annex L, L2 Organic Impurities.

c) Requirements specified in CSA A3001, Clause 4.4.4 Limestone Addition to Portland-limestone and Blended Portland-limestone Cement, bullet a) for calcium carbonate content.

d) Restricted to a maximum of 15% of the cement by mass.

1355.05.03 Associated Hardware

Associated hardware shall be according OPSS 905. All hardware shall be non-corroding or be galvanized according to ASTM A153.

Surfaces of hardware located within 40 mm of the concrete surface shall be chromate coated over an electro-deposited coating of zinc according to ASTM B633.

1355.05.04 Burlap

Burlap shall be according to OPSS 1306.

1355.05.05 Cementing Materials

Cementing materials shall be according to OPSS 1350.

1355.05.03 Concrete

Concrete for elements shall be according to OPSS 1350 with the following additions and amendments:

a) For wet cast concrete, the maximum air void system spacing factor of the hardened concrete, when tested according to LS-432, shall be 0.200 mm.

b) For dry cast concrete, the air void system requirements for plastic and hardened concrete do not apply.

c) When salt scaling resistance is specified for acceptance, loss of surface mass due to scaling when tested according to LS-412 shall not exceed 0.8 kg/m^2.

1355.05.04 Concrete Sealers

Concrete sealers, if required, shall be from the Ministry's List of Acceptable Sealers. The list shall be obtained from the Contract Administrator.

1355.05.05 Elastomeric Coating

Elastomeric coating shall be according to OPSS 1213.

1355.05.06 Embedded Bearing Plate

The embedded bearing plate and shear connectors shall be according to OPSS 906.

Shear connectors shall be welded to the embedded bearing plates prior to galvanizing.

All surfaces shall be hot dipped galvanized according to ASTM A153 or shall be zinc metallized according to CSA G189.

1355.05.07 Glass Fibre Reinforced Polymer

Glass fibre reinforced polymer (GFRP) shall be according to OPSS 1640.

1355.05.08 Moisture Vapour Barrier

The moisture vapour barrier shall be white opaque polyethylene film according to ASTM C171 and shall not be less than 100 µm thick.

1355.05.09 Post-Tensioning Material

Post-tensioning material, including grout, shall be according to OPSS 910.

1355.05.10 Prestressing Steel

Prestressing steel shall be low alloy steel bar or uncoated, low relaxation 7-wire strand according to OPSS 1440.

1355.05.11 Proprietary Patching Materials

Proprietary patching materials shall be from the Ministry's List of Concrete Patching Materials. The list shall be obtained from the Contract Administrator.

1355.05.12 Steel Reinforcement and Mechanical Connectors

Steel reinforcement and mechanical connectors shall be according to OPSS 1440.

1355.05.13 Water

Water used for production, curing, including steam curing and pre-soaking of burlap, and water used in proprietary patching materials shall be according to OPSS 1302.

1355.06 EQUIPMENT

1355.06.01 General

Equipment and tools made of aluminum shall not come in contact with the plastic concrete.

1355.06.02 Chipping Hammers

Chipping hammers shall be hand-held and shall have a maximum weight of 9.0 kg and a maximum piston stroke of 102 mm. All hammers shall have the manufacturer's name and model number legibly engraved on them by the manufacturer. The manufacturer's published specifications shall be the sole basis for determining weight and piston stroke.

1355.06.03 Consolidating Equipment

Consolidating equipment shall be according to OPSS 904.

1355.06.04 Contact Thermometers

Contact thermometers shall have an accuracy of ± 0.5°C.

1355.06.05 Hand Finishing Tools

Hand finishing tools shall be according to OPSS 904.

1355.06.06 Pretensioning and Post-Tensioning Equipment

Pretensioning equipment shall be according to CSA A23.4. Post-tensioning equipment shall be according to OPSS 910.

1355.06.07 Temperature Monitoring and Recording System

The temperature monitoring and recording system shall provide unalterable records of temperature during the temperature monitoring period. Prior to fabrication, the temperature monitoring and recording system shall be confirmed by the Contract Administrator, in writing, to be acceptable.

Temperature sensors and associated instrumentation shall:

a) Have an accuracy of ± 1.5°C;

b) Record temperatures at time intervals not exceeding 15 minutes; and

c) Digitally display the temperature.

1355.07 PRODUCTION

1355.07.01 General

The Contract Administrator shall be notified in writing at least 14 Days prior to commencement of fabrication.

A single element shall be fabricated from the same materials and mix design.

Precast concrete shall be wet cast unless otherwise specified in the Contract Documents, except for MSE, which may be wet cast or dry cast depending on the designation on the DSM list for the MSE used.

1355.07.02 Precast Plant Certification

Elements shall be fabricated by a precast plant certified by CSA or CPCQA according to the requirements specified in Table 1.

If concrete is supplied by a ready-mix concrete plant, the concrete production facility shall be certified by the Ready Mixed Concrete Association of Ontario (RMCAO).

1355.07.03 Formwork and Falsework

Formwork and falsework shall be according to OPSS 919 and CSA A23.4. Formwork shall be fabricated to meet the dimensional tolerances and finishes specified in the Contract Documents. Textile form liners shall not be used.

For girders, formwork for exterior surfaces shall be fabricated steel, except for box girders of non-standard width for which wood forms may be used.

1355.07.04 Prestressed Elements

1355.07.04.01 Hold Down Devices

Hold down devices shall permit the free movement of the strand. The device shall be tested by its manufacturer to ensure that the final stress along the full length of the strand is uniform.

1355.07.04.02 Strand Splicing

Strands shall not be spliced.

1355.07.05 Reinforcement, Mechanical Connectors, and Associated Hardware

1355.07.05.01 Placement

Steel reinforcement, mechanical connectors and associated hardware shall be according to OPSS 905, with the following exceptions and additions:

a) MTO form PH-CC-701, Request to Proceed upon completion of the installation of the steel reinforcement and mechanical connectors is not required.

b) The placing tolerances for prestressed concrete girders shall be according to the following:

i. Vertical position of prestressing strands: + 5 mm, - 10 mm
ii. Length of debond on prestressing strands: ± 50 mm
iii. Projections of reinforcing steel bars and strands at girder ends: ± 25 mm
iv. Stirrup spacing:

(1) ± 15 mm when spacing is 100 mm or less
(2) ± 25 mm when spacing is greater than 100 mm and less than 300 mm
(3) ± 30 mm when spacing is 300 mm or greater

GFRP reinforcement and associated hardware shall be according to OPSS 950, when use of GFRP is specified in the Contract Documents.

Under no circumstances shall reinforcement be inserted into plastic concrete.

1355.07.05.02 Welding

Welding of steel hardware, including shear studs, shall be according to CSA W59 and shall be performed by a welder qualified by the Canadian Welding Bureau (CWB) working for a company certified according to CSA W47.1, Division 1 or 2.

Welding of prestressing strands shall not be permitted.

Tack welding of steel reinforcement shall not be permitted.

Resistance welding shall only be used if approved by the Owner.

Welding of reinforcing steel bars shall be according to OPSS 905.

For prestressed elements, welding within 3 m of the prestressing steel is not permitted unless the prestressing steel is fully encased in concrete that has reached the transfer strength specified in the Contract Documents. Welding equipment shall not use any components of the prestressing system or any component in contact with the prestressing system as an electrical ground.

1355.07.06 Placing of Sheaths and Anchorages for Prestressed Elements

When elements are to be post-tensioned, the sheaths and anchorages shall be according to OPSS 910.

1355.07.07 Markings - Embossed

For culverts, the MTO site number shall be embossed on the end pieces, in an area that will remain visible, using numbers and letters 30 mm wide, 35 mm high and 5 mm deep on each element.

1355.07.08 Production of Concrete

Production of concrete shall be according to the General, Temperature Control, Mixing Time and Mixing Rate, and Delivery subsections of the Production section of OPSS 1350, with the following additions:

a) When there are multiple batches of concrete in a single ready-mix truck, hopper or other container, discharge times shall be measured from the time of introduction of water to cement for the first batch of concrete in the truck, hopper or other container. Discharge into the formwork of all concrete in the truck, hopper or other container shall be completed within 1.5 hours, except when the air temperature exceeds 28°C and the concrete temperature exceeds 25°C, the discharge into the formwork shall be completed within 1 hour.

b) A delivery ticket is not required except when concrete is supplied by a ready-mix concrete plant.

1355.07.09 Materials Sampling and Testing - Plastic Concrete

1355.07.09.01 Wet Cast Concrete

For wet cast concrete, sampling and testing of the plastic concrete for slump, air content, and temperature shall be according to the Material Sampling and Testing subsection of OPSS 1350, except the minimum frequency of testing shall be as follows:

a) For concrete supplied by an external concrete supplier and delivered by a ready-mix truck: once for each of the first three trucks, until satisfactory control is established, and then once every third truck.

b) For batches of concrete produced at the precast plant and delivered by a ready-mix truck: once for each of the first three trucks, until satisfactory control is established, and then once every third truck.

c) For batches of concrete produced at the precast plant, and not delivered by a ready-mix truck: once for each of the first five batches of concrete, until satisfactory control is established, and then once every fifth batch.

d) For batches of concrete produced at a precast plant with an integrated mixing and delivery system (e.g. Autocor): once for every second batch for the first six batches, until satisfactory control is established, and then once every 7 m^3 of concrete.

Satisfactory control is established when three or five consecutive tests of concrete, as specified above, are within the specified requirements, without adjustments. If any adjustments are required or conducted, testing shall continue until three or five consecutive tests, as specified above, meet the requirements with no adjustments. Satisfactory control shall be established each Day or when there is a break in production longer than 1.5 hours.

Testing of plastic concrete shall be carried out as close as possible to the location of discharge of concrete into the formwork.

The results of the plastic tests shall be recorded and submitted in the precast report.

1355.07.09.02 Dry Cast Concrete

For dry cast concrete, the concrete shall be tested for temperature according to OPSS 1350. The minimum frequency of testing shall be once for each Day of production.

1355.07.10 Placing of Concrete

1355.07.10.01 General

The method of transporting, placing, and consolidating the concrete shall be such as to prevent segregation and formation of cold joints.

Devices for placing and transporting concrete shall not be made of aluminum.

Concrete placing and transporting devices shall not be supported by the reinforcement.

Concrete shall be deposited within 0.5 m of the top of the reinforcing bars and 1.5 m horizontally of its final position, except for culverts where the concrete shall be deposited within 2.5 m horizontally of its final position.

Concrete shall be placed at a steady rate such that a monolithic concrete is obtained without the formation of cold joints or pour lines.

When there is an interruption in placing concrete greater than 20 minutes, the top of the formwork shall be covered with wet burlap to maintain 100% relative humidity above the concrete. Any interruption in placing concrete shall not exceed 40 minutes. The Contract Administrator shall be notified of any interruption that may result in a cold joint or any interruption exceeding 40 minutes. A proposal for remedial action shall be submitted to the Contract Administrator for approval by the Owner.

1355.07.10.02 Concrete Placing Restrictions

All debris shall be removed from the area where concrete is to be placed.

All surfaces against which concrete is to be placed shall be free of standing water, ice and snow. Deicing chemicals shall not be used to remove ice and snow.

All surfaces against which concrete is to be placed shall be clean, sound, and free from any loose particles, laitance and any other foreign substance or debris.

The temperature of the formwork, reinforcement or any other material against which concrete is to be placed shall be greater than or equal to 5°C and shall not exceed 30°C. Temperature measurements of material against which concrete is to be placed shall be taken no more than 10 minutes prior to concrete placement, for each element. Temperature measurements shall be made with a contact thermometer. Temperature measurements shall be recorded and included in the precast report.

Fresh concrete shall be protected from contact with rain or snow.

1355.07.10.03 Consolidation

Internal or external vibrators or both shall be used to thoroughly consolidate the concrete at the point of deposit within 15 minutes of placement.

Concrete shall be thoroughly consolidated around all reinforcement.

For wet cast concrete, each layer of concrete shall be vibrated. Vibrators shall extend into the previous layer to produce a homogenous mixture at the layer interface and prevent the formation of pour lines or cold joints.

Vibration shall not be used to make the concrete flow or to spread the concrete more than 1.5 m from the point of deposit.

The requirements of this clause do not apply to self-consolidating concrete (SCC), when accepted for use by the Owner.

1355.07.10.04 Concrete Finishing

Finishing of the concrete surface shall be carried out immediately following placement and consolidation.

No water or other material shall be applied to the concrete surface or the finishing tools to aid in the finishing.

The concrete shall be struck off to the required dimensions and cross-section and shall be hand finished with a float. Excessive mortar or bleed water shall not be drawn to the surface by over finishing. Bleed water shall not be worked into or incorporated into the concrete surface.

Except as indicated below, finished surfaces shall be smooth, free from open texturing, undulations, projections, and ridges.

Concrete surfaces against which new concrete is to be placed shall be:

a) Left with a rough surface finish where the depth of the indentations are at least 5 mm and the spacing is not greater than 15 mm; and

b) Abrasive blast cleaned according to OPSS 929, except that abrasive blast cleaning shall be carried out at the precast plant prior to shipping the elements. For girders, the following surfaces shall be abrasive blast cleaned at the precast plant:

    i. Top portion of the girders.
    ii. The portion of the sides and end of the girder against which new concrete is to be placed.

When placing outdoors, newly placed plastic concrete shall not be exposed to precipitation or runoff during placement, consolidation, or finishing.

The requirement to hand finish the concrete with a float may not apply to SCC, where accepted for use by the Owner.

1355.07.11 Curing

1355.07.11.01 General

Moist curing of exposed surfaces shall commence immediately after concrete finishing of each element and shall be applied within 2 to 4 m of concrete placement.

For girders without silica fume, the moist curing period shall consist of 48 hours of moist curing followed by a 48-hour period of a moisture retention. After completion of the moist curing period, girder surfaces shall be completely covered by moisture vapour barrier to protect the girders from moisture loss for a period of 48 hours. Alternatively, moist curing methods may be continued during the moisture retention period.

For all other concrete, the minimum moist curing period shall be 4 Days, except for concrete containing silica fume which shall have a 7 Day minimum moist curing period. Curing in cold weather conditions shall be as specified in the Cold Weather Protection Period subsection.

1355.07.11.02 Moist Curing

1355.07.11.02.01 General

Moist curing shall be sufficient to keep all surfaces of the concrete in a continuously wet condition, with no dry areas, by applying one or a combination of the following methods:

a) Curing with burlap and water.

b) Continuous water application, e.g., mist.

c) Steam curing and other application of heat.

d) Curing by means of immersion in water.

1355.07.11.02.02 Curing with Burlap and Water

Burlap shall be pre-soaked by immersing it in water for a period of at least 24 hours immediately prior to placing. Two layers of burlap shall be applied to the surface of the concrete. Burlap strips shall overlap 150 mm. Burlap shall be held in place without marring the surface of the concrete.

The burlap shall be maintained in a continuously wet condition throughout the curing period by means of a soaker hose. The soaker hose shall be turned on as soon as possible, when running water will not cause damage to the concrete surface. The burlap shall be covered with a layer of moisture vapour barrier within 3 hours of placing of the concrete, in a manner that prevents deformation of the surface of the concrete.

Air flow in the space between the moisture vapour barrier and the burlap shall be prevented.

Water shall not be allowed to drip, flow or puddle on the concrete surface until the concrete has hardened sufficiently to resist damage.

1355.07.11.02.03 Steam Curing and Other Application of Heat

There shall be a delay period prior to application of steam or heat above 30°C, as follows:

a) For concrete not containing a retarder, the delay period shall be 4 hours.

b) For concrete containing a retarder, the delay period shall be 6 hours.

c) A shorter delay period may be used if it has been demonstrated to the satisfaction of the Owner that initial set occurs earlier. Time of initial set shall be:

   i. Demonstrated by testing according to ASTM C403, using the same mix design, mixing equipment, concrete temperature, and ambient temperature as when producing the elements.
   ii. Carried out in the presence of the Contract Administrator or the Owner's representative.
   iii. Demonstrated up to two times per year, upon request by the Owner.

The element shall be heated evenly. Steam, heat or forced air shall not be directed on the concrete, forms, or steel reinforcement. There shall be free circulation of steam, heat and forced air around the top, sides, and ends of the element. Concrete surfaces shall not be exposed to combustion gases during the curing cycle.

1355.07.11.03 Formwork Removal During Curing

Formwork shall be removed from bridge deck elements and MSE elements within 24 hours of concrete placement and all surfaces previously covered by forms shall be immediately moist cured as specified above for the remainder of the specified curing period.

After formwork is removed for girders, formed surfaces shall be moist cured for the remainder of the 48-hour moist curing period, and no less than 24 hours.

For all other elements, formwork shall be removed within 4 Days of concrete placement and the concrete shall be moist cured for the remainder of the minimum moist curing period and no less than 24 hours.

Concrete may be exposed to ambient conditions, during the moist curing period, as specified in the Exposure subsection.

1355.07.11.04 Records of Inspection of Moist Curing

Inspections shall be carried out during the curing period to verify that curing is as specified in this specification.

Moist curing inspection records shall be maintained and submitted as part of the precast report. As a minimum, records of moist curing shall include:

a) Identification of the person checking the moist curing system;

b) The date and time that it was verified; and

c) Photographic documentation, including the date and time stamp, of the curing chamber in operation during the curing period as follows, as a minimum:

   i. Photographs shall be taken every 8 hours for the first 24 hours of the curing period.
   ii. Photographs shall be taken every 24 hours for the remainder of the curing period.

1355.07.12 Cold Weather Protection Period

If cold weather conditions are present at the end of the curing period, a cold weather protection period shall be required.

During the cold weather protection period, the elements shall be provided with protection from cold weather and moisture loss prior to unprotected exposure to cold weather conditions.

At a minimum, the cold weather protection period shall be:

a) An additional 24 hours immediately following the curing period; and

b) Extended beyond 24 hours, if required to meet the requirements in the Control of Temperature and Temperature Difference subsection.

The conditions shall be monitored, and the protection system modified as required to control the temperature and temperature difference as specified.

1355.07.13 Control of Temperature and Temperature Difference

1355.07.13.01 General

The temperature monitoring period shall be the curing period and, if applicable, the cold weather protection period.

During production and the temperature monitoring period, all necessary action shall be taken to maintain temperatures within the following specified limits:

a) The maximum concrete temperature shall not exceed the values specified in Table 2.

b) The concrete temperature shall not fall below 10°C before the end of moist curing.

c) The concrete temperature shall not fall below 0°C before the end of the cold weather protection period.

d) The temperature difference, as measured between temperature sensors at the following locations, shall not exceed 20°C:

   i. Internal concrete temperature and the corresponding surface concrete temperature.
   ii. Internal concrete temperatures at different locations within the element.

e) The maximum cooling rate of concrete shall not exceed 15°C per hour until the concrete is not more than 20°C above the air temperature. Air temperature is the temperature next to the concrete, within the curing enclosure.

1355.07.13.02 Temperature Monitoring

During the temperature monitoring period, the concrete and air temperatures shall be monitored and recorded.

The location of temperature sensors shall be as specified in Table 3.

Recording of concrete and air temperatures shall begin at the start of concrete placement. The temperature shall be recorded automatically at time intervals not exceeding 15 minutes until the end of the temperature monitoring period. The temperature monitoring system shall be left in place until the end of the temperature monitoring period.

Concrete and ambient air temperature readings shall be monitored and verified regularly during the temperature monitoring period. Necessary action shall be taken to maintain the temperature within the specified limits. If the temperature exceeds the specified requirements, the Contract Administrator shall be notified immediately.

When requested, the Contract Administrator and/or any other Owner's representatives shall be provided access to verify temperature readings and temperature sensor function.

1355.07.13.03 Temperature Monitoring Records

At the end of the temperature monitoring period, the following documentation for the duration of the temperature monitoring period shall be submitted to the Contract Administrator in the precast report:

a) A completed MTO Form PH-CC-117, Concrete Temperature Record;

b) Location of temperature sensors, including a sketch showing the location of all temperature sensors, with each sensor labeled using identifiers that correspond to the graphical plots and unmodified original output files;

c) A complete temperature record for all temperature sensors, and a graphical plot of temperature versus time for each sensor;

d) A complete temperature record showing the difference between the centre of the concrete component and the surface of the concrete component, and a graphical plot of the differential temperature versus time;

e) The unmodified original output file generated by the data logger; and

f) Any actions taken to maintain control of temperature.

The format of the temperature plots shall be acceptable to the Owner.

1355.07.14 Exposure

During moist curing and cold weather protection periods, the element may be exposed for a maximum total period of 1 hour per Day for the purposes of formwork removal, inspection, or relocation within the plant, except for indoor precast concrete plants, where the exposure period shall not exceed 2 hours per Day.

On the Day formwork is removed, the moist curing may be suspended during the 1-hour exposure period, or 2-hour exposure period for indoor precast concrete plants, except for concrete containing silica fume. For concrete containing silica fume, continuous moist curing shall be applied throughout the exposure period.

1355.07.15 Stripping Strength

For each element, it shall be demonstrated that the stripping strength specified in the Working Drawings has been achieved prior to stripping the formwork.

The Contractor, when requested by the Owner, shall participate in standard cylinder correlation strength testing programs conducted by the Owner.

1355.07.16 Prestressed Elements

1355.07.16.01 Transfer of Prestressing Force

The prestressing force shall not be transferred to the elements until the transfer strength specified in the Contract Documents has been reached. The prestressing force shall be transferred according to the strand release sequence specified on the Working Drawings.

1355.07.16.02 Treatment of Ends of Prestressed Elements

The prestressing strands at ends of the elements that are to be encased in concrete shall be cut off 25 mm beyond the ends, unless otherwise specified in the Contract Documents. The prestressing strands at the end of elements that are not to be encased in concrete shall be cut back to recess the cable 25 mm from the end, unless otherwise specified in the Contract Documents. The recess shall be cleaned, filled with a proprietary patching material, and the ends of the elements coated with an elastomeric coating.

1355.07.17 Markings - Stencilled

Each element shall be marked with the following information:

a) Name or trademark of the manufacturer.

b) Date of manufacture (yyyy-mm-dd).

c) Unique number.

d) Lot number.

e) Certification stamp according to the requirements of the CPCQA or CSA Certification Program, except for MSE and noise barrier.

f) Identification of plant if manufacturer has more than one plant.

g) For culverts, the word “TOP” on the top surface of the element. This requirement shall be waived if the manufacturer installs lifting devices in the top of the culvert only.

The markings shall be stencilled, using indelible ink or waterproof paint, within 24 hours of stripping forms. Any markings on a surface that would be visible after installation shall not be permitted, except for concrete barriers, where the markings shall be on the top of the barrier.

1355.07.18 Surface Finish

1355.07.18.01 General

Concrete surfaces shall not be treated with cement slurry or paste.

1355.07.18.02 Exposed Surfaces

The appearance of the concrete and repairs shall be uniform in colour, pattern, and texture when viewed from a distance of 15 m. Material, including all patching materials, shall be selected to achieve uniformity of colour and appearance.

All projections, such as fins and bulges, and all blemishes, such as stains and rust marks shall be removed.

1355.07.18.03 Surface Tolerance

Element surfaces when tested with a 3 m long straight edge placed anywhere in any direction on the surface, shall meet the following requirements:

a) For formed concrete surfaces of MSE, the driving surface of precast concrete pavement slabs and the driving surface of precast bridge deck elements exposed to traffic, there shall be no gap greater than 3 mm between the bottom of the straight edge and the surface of the concrete.

b) For all other formed and unformed concrete surfaces there shall be no gap greater than 6 mm between the bottom of the straight edge and the surface of the concrete.

1355.07.19 Defects, Deficiencies and Repairs

1355.07.19.01 Inspection

All elements shall be routinely inspected for any defects and deficiencies by the Contractor all defects and deficiencies shall be documented and submitted in the precast report.

Any element with defects or deficiencies meeting the conditions identified in Table 4 shall be repaired according to the repair method specified. Such repairs do not require proposals or Owner approval prior to repair.

Any other type of repair requires a repair proposal, according to the Repair Proposal subsection, to be submitted to the Contract Administrator. Repairs shall not be carried out until the repair proposal is accepted by the Owner.

1355.07.19.02 Documentation of Inspection and Repairs

Documentation of inspection by the Contractor and repairs shall include the following for each defect or deficiency and repair:

a) The type of defect or deficiency, and the location, size, and frequency.

b) Causes of the defect or deficiency.

c) Preventative actions taken to address the causes for future production.

d) Details of repairs, including:

   i. Identification of repaired element,
   ii. Whether repair is by standard method, as specified in this specification, or by proposal accepted by the Owner,
   iii. Type of defect or deficiency that is repaired,
   iv. Identification of the limits of repair for each area,
   v. Repair method and materials used, and
   vi. Colour photographs, with date, of the defect or deficiency prior to and after the repair.

1355.07.19.03 Repair Proposal

1355.07.19.03.01 General

The proposal for repairs shall include the following, as a minimum and shall be signed and sealed by an Engineer:

a) Identification of the element and description of the defect(s) or deficiencies.

b) High resolution photographs and detailed sketches showing the width, length, depth, location, nature and frequency of any defect(s) or deficiencies.

c) An assessment of any impact of the repaired defect(s) or deficiencies on durability, structural adequacy, and integrity of the element or on the structure.

d) A detailed repair plan, including materials, method, and equipment to be used.

e) Verification that the repair plan complies with the applicable standards for the type of work.

f) All relevant supporting information, including material test results, field measurements and observations, production records, photographs, and structural analysis calculations, used for determining that the performance and function originally expected from the element shall be met.

g) Cause(s) of the defect or deficiency and corrective action to be taken to prevent recurrence of the defect in future production, delivery, or installation.

If the repair proposal is deemed acceptable by the Owner, the element shall be repaired according to the proposal. Repairs shall not be carried out without the prior written acceptance of the proposal by the Contract Administrator.

1355.07.19.03.02 Additional Requirements for Repair Proposals for Girders

The repair proposal for girders shall also include an assessment of any impact on the durability, structural adequacy, and integrity of the girder or on the structure when the following conditions apply:

a) Low Cover: Any cover readings less than 40 mm and greater than 35 mm along the soffit of the girder at locations other than bearing cutouts;

b) High Cover: Any cover readings less than 70 mm and greater than 60 mm along the soffit of the girder at locations other than bearing cutouts; or

c) High Cover: Any cover readings less than 55 mm and greater than 45 mm at all locations along the girder other than bearing cutouts.

1355.07.19.04 Assessment of Repair

At the discretion of the Owner, additional visual inspection or other investigative measures may be required to assess the acceptability of the repair. The Owner may require removal of cores for testing by the Owner. The work shall be carried out at no additional cost to the Owner.

The filling of core holes shall be according to the Filling of Core Holes subsection in OPSS 1350.

1355.07.20 Concrete Cover

The concrete cover and tolerance for concrete cover over steel reinforcement of elements shall be according to OPSS 905, or as specified in the Contract Documents.

The Contractor shall carry out a covermeter survey on all elements at the precast plant, until satisfactory control is established. For each element type, satisfactory control shall be established when three consecutive elements of the same design are within the specified tolerances. After satisfactory control has been established, testing shall be carried out on every fifth element for girders, culverts and bridge elements. For all other elements, after satisfactory control has been established, testing shall be carried on a minimum of five additional elements per lot, as defined in Lot Size subsection. If testing indicates that cover measurements for an element do not meet the specified tolerances, testing shall resume on each element until satisfactory control is re-established.

For girders, concrete cover readings shall be taken at locations 600 mm from both ends, at mid-span, and at intervals not exceeding 5 metres along the length of the girder.

For I-girders, readings shall be taken at each location, as detailed below:

a) Top of web, both sides.

b) Bottom of web, both sides.

c) Mid-height of each side of bottom flange for CPCI girder type, and on top of each side of bottom flange, 150 mm from the edge of the flange for NU girder type.

d) Bottom of girder, located at 150 mm from both edges of flange.

For box girders, readings shall be taken at each location, as detailed below:

a) Top of web, exterior sides.

b) Bottom of web, exterior sides.

c) Top and bottom of girder, located at 400 mm from both edges of flange.

For culverts, the concrete cover readings shall be taken evenly spaced across the surface of the concrete at grid points spaced 1 to 3 m along the longitudinal and transverse axes. A minimum of 20 measurements shall be taken for each element.

For bridge elements, concrete cover readings shall be taken at locations 500 mm from all corners in a 1 m grid pattern along all surfaces of the element. For bridge elements less than 1 m long, a minimum of two measurements shall be taken along each grid line.

The results of the concrete cover survey shall be included in the precast report.

The Contract Administrator shall be notified in writing when the elements are ready for the quality assurance concrete covermeter verification.

1355.07.21 Dimensional Tolerances

Dimensional tolerances shall be as specified in the Contract Documents. Where dimensional tolerances are not specified elsewhere in the Contract Documents, the maximum allowable dimensional variation for the elements shall be 1:800 or ± 5 mm, whichever is greater.

Girders shall meet the dimensional tolerances of Table 5. Culverts shall meet the dimensional tolerances of Table 6. Bridge elements shall meet the dimensional tolerances of Table 7.

The Contractor shall carry out, at the precast plant, dimensional measurements to determine compliance with the dimensional tolerance requirements. For girders, culverts and bridge elements, each element in a lot shall be measured. For all other elements, a minimum of five element per lot, as defined in Table 8, shall be measured.

The Contract Administrator shall be notified in writing when the elements are ready for the quality assurance dimensional measurement verification.

1355.07.22 Material Sampling and Testing

1355.07.22.01 Contractor Sampling for Quality Control Purposes

The Contractor may obtain samples of plastic concrete for quality control purposes. Sampling or destructive testing of hardened concrete in the work for quality control purposes shall not be carried out without obtaining the written permission of the Owner in advance. The Owner's denial of permission shall not absolve the Contractor for the quality of concrete.

1355.07.22.02 Sampling of Steel Reinforcement

Samples of steel reinforcement shall be provided to the Owner according to OPSS 905.

1355.07.22.03 Sampling of Water, Admixtures, and Cementing Materials

Samples of all water, admixtures, and cementing materials shall be provided to the Owner for testing, according to OPSS 1350.

1355.07.22.04 Sampling of Concrete for Acceptance Testing

1355.07.22.04.01 General

Concrete shall be sampled on a lot basis as specified in Tables 8 and 9, the Coring for Acceptance Testing clause, and the Lot Size subsection of this specification. Elements from which samples are taken shall be randomly selected by the Contract Administrator for each lot. Cores and sawn samples shall be removed in the presence of the Contract Administrator. Cores and sawn samples shall be given to the Contract Administrator or Owner's representative immediately for transportation to the designated laboratory for testing by the Owner.

1355.07.22.04.02 Notification

A list of elements within a lot and the element identification numbers shall be submitted to the Contract Administrator within 24 hours of the completion of a lot, to facilitate selection by the Contract Administrator of elements for acceptance testing.

1355.07.22.04.03 Additional Requirements for MSE

For MSE elements less than 2 m in vertical height, one additional element of the most common size shall be supplied for each lot for sampling of cores and sawn samples. The element from which the test specimens are taken shall be randomly selected from the lot by the Contract Administrator. The element used for sampling shall be clearly labelled and shall be retained until Contract Completion for sampling for referee testing, if invoked.

For MSE elements with any dimension greater than 2 m, cores and sawn samples shall be removed from portions of the elements to be installed below grade, except where no portion of the elements is below grade, cores and sawn samples shall be taken from locations as directed by the Contract Administrator. The element to be tested shall be randomly selected by the Contract Administrator and the locations of cores and sawn samples shall be determined by the Contract Administrator. The core and sawn sample removal locations shall be repaired as specified in the Coring for Acceptance Testing clause.

At the discretion of the Owner, an additional MSE element shall be provided of a different element type for acceptance testing.

1355.07.22.04.04 Cylinders for 28-Day Compressive Strength Testing

When cylinders are specified for acceptance testing as specified in Table 8, the Contractor shall cast, cure, and transport cylinders for 28-Day compressive strength testing by the Owner according to CSA A23.2-3C with the following exception:

a) Cylinders shall be cured with the element prior to delivery to the laboratory.

All concrete test cylinders shall be cast in moulds. The moulds shall be single use moulds according to CSA A23.2-1D and made of plastic with a lid. The lids shall be chemically and physically compatible with the concrete and shall provide watertight closure for the moulds.

Test information shall be recorded on MTO form PH-CC-322, Concrete Construction Report and shall be submitted with each set of concrete cylinders.

The concrete temperature shall be continuously recorded and monitored immediately adjacent to the cylinders during the field-curing period. The maximum time interval for recording the temperature shall be every 15 minutes.

1355.07.22.04.05 Submission of Cylinder Curing Records

Cylinder curing temperature records shall be submitted to the Contract Administrator at the completion of the field-curing period.

1355.07.22.04.06 Transfer Strength

For prestressed elements, prior to transfer of the prestressing force, it shall be demonstrated that the transfer strength specified in the Contract Documents has been achieved. The Contractor, when requested by the Owner, shall participate in standard cylinder correlation strength testing programs conducted by the Owner.

1355.07.22.04.07 Coring for Acceptance Testing

Cores for evaluation of compressive strength, air void system (AVS) parameters and rapid chloride permeability (RCP) shall be required as specified in Table 8, for testing by the Owner.

The Contract Administrator shall be notified in writing, a minimum of 5 Business Days in advance, of when a lot(s) is ready to be cored.

The location of cores within the element, the number of cores and the required dimensions of the test specimens shall be as specified in Table 8 and Table 9 and as directed by the Contract Administrator. For elements with thickness that is less than the specified dimension, the full depth of the element shall be cored.

Cores shall be removed when the concrete is between 7 to 10 Days of age. Samples shall be removed in the presence of the Contract Administrator or Owner's representative. No core shall be taken within 250 mm of any joint or edge or within a distance 500 mm from another core. All cores of the same set shall be removed at a location no more than 3 m from the location of the first core for that set.

Coring shall be carried out according to CSA A23.2-14C. Cores shall not contain steel, GFRP reinforcement or other embedded material. A covermeter capable of detecting the type(s) of reinforcing materials in the element shall be used to establish the location of reinforcement and other embedded material prior to coring.

The Contract number, lot number, and element identification number shall be marked legibly on each core with durable ink. Each core shall be placed in a plastic bag, sealed to prevent loss of moisture, and fitted with a security tag provided by the Contract Administrator. All acceptance cores shall immediately be given to the Contract Administrator, along with the transmittal MTO forms PH-CC-340, Field Sample Data Sheet - Concrete Section and PH-CC-433A, Concrete Mix Design Form A, for transportation to the designated laboratory.

The core holes shall be filled, within 3 Days, according to the Filling of Core Holes subsection of OPSS 1350.

1355.07.22.04.08 Coring for Referee Testing

Cores for referee testing shall have the same dimensions as the acceptance test specimens.

Referee testing of compressive strength shall be carried out on a set of three cores taken within 3 Business Days of invoking referee testing. The cores shall be taken from the same element which represents the acceptance cylinders or cores. Samples shall be removed in the presence of the Contract Administrator or Owner's representative.

For girders, a set of three cores for referee testing of compressive strength shall be taken from the girder which the acceptance cylinders represent. Referee cores shall immediately be given to the Contract Administrator for transportation to the designated laboratory.

The location of cores within the element shall be as directed by the Contract Administrator. The required dimensions of the cores shall be as specified in Tables 8. For elements with thickness that is less than the specified dimension, the full depth of the element shall be cored.

No core shall be taken within 250 mm of any joint or edge or within a distance 500 mm from another core. No core shall be taken through the waterproofing system for elements that are installed. All cores of the same set shall be removed at a location no more than 3 m from the location of the first core for that set.

Coring shall be carried out according to CSA A23.2-14C. Cores shall not contain steel, GFRP reinforcement or other embedded material. A covermeter capable of detecting the type(s) of reinforcing materials in the element shall be used to establish the location of reinforcement and other embedded material prior to coring.

The Contract number, lot number, and element identification number shall be marked legibly on each core with durable ink. Each core shall be placed in a plastic bag, sealed to prevent loss of moisture, and fitted with a security tag provided by the Contract Administrator. All referee cores shall immediately be given to the Contract Administrator or Owner's representative, along with a transmittal form indicating that they are for referee testing and MTO forms PH-CC-340, Field Sample Data Sheet - Concrete Section and PH-CC-433A, Concrete Mix Design Form A.

The core holes shall be filled, within 3 Days, according to the Filling of Core Holes subsection of OPSS 1350.

1355.07.22.04.09 Salt Scaling Sawn Samples

Sawn samples for evaluation of salt scaling resistance shall be required for MSE and concrete barrier.

When specified in Table 8 for acceptance, two sawn samples shall be removed from the element as directed by the Contract Administrator, for testing of salt scaling resistance by the Owner according to LS-412.

Two additional sawn samples shall be removed from the element and retained by the Owner for referee testing, as specified in Table 8.

Sawn samples for testing shall be removed when the concrete is between 7 to 10 Days of age. Samples shall be removed in the presence of the Contract Administrator or Owner's representative.

The Contract number, lot number, element identification shall be marked legibly on each sawn sample with durable ink. Each sawn sample shall be placed in a plastic bag, sealed to prevent loss of moisture and placed into clear polyethylene security bags supplied by the Owner. All sawn sample shall immediately be given to the Contract Administrator or Owner's representative, along with the following MTO forms:

a) PH-CC-340, Field Sample Data Sheet - Concrete Section; and

b) PH-CC-433A, Concrete Mix Design Form A.

For elements without textured architectural finish, the salt scaling test shall be conducted on the formed front face.

For elements with textured architectural finish, the salt scaling test shall be conducted on the back face of the element.

The sawn sample holes shall be filled, within 3 Days, according to the Filling of Core Holes subsection in OPSS 1350, except for MSE elements that will not be used in the Work.

1355.07.23 Access for Quality Assurance

Electrical power, scaffolding, protection from the weather, and unhindered access for inspection and testing of all the work, including assessment of repairs, shall be provided to the Contract Administrator or Owner's representative.

Any debris and obstructions shall be removed to allow access for the purposes of covermeter and dimensional measurements or inspection.

The Contract Administrator or Owner's representative shall be granted access to inspect the elements after delivery to the site, and prior to installation.

1355.07.24 Manufacturer's Certificate of Conformance

A MTO form PH-CC-821, Manufacturer's Certificate of Conformance, for each individual shipment of elements, indicating that the elements have been constructed in conformance to the requirements of the Contract Documents shall be submitted to the Contract Administrator prior to shipping.

1355.07.25 Manufacturer's Precast Report

1355.07.25.01 General

A precast report shall be submitted to the Contract Administrator for each shipment of elements, a minimum of 5 Business Days prior to shipping the elements from the precast plant.

The precast report shall contain the following information:

a) List of elements including their identification number, lot number and description.

b) Mill certificates for the steel reinforcement used in the elements, according to OPSS 1440.

c) Summary of all measurements and inspections carried out prior to concrete placement to verify compliance with the Contract Documents including reinforcement placement, and other pre-pour checks.

d) Temperature records at the time of concrete placement for formwork and steel reinforcement.

e) Temperature monitoring records for the concrete as specified in the Temperature Monitoring Records clause.

f) Record of inspection of moist curing.

g) Summary of the following material test results for plastic concrete:

   i. For wet cast concrete: air content, slump, and concrete temperature.
   ii. For dry cast concrete: concrete temperature.

h) Summary of the following material test results for hardened concrete:

   i. Transfer strength, if applicable;
   ii. Stripping strength; and
   iii. Confirmation of the projected 28-Day compressive strength.

   If test results are not available at the time of shipping, they shall be submitted within 4 Business Days following completion of testing.

i) Summary of all measurements and inspections required by the Contract Documents, including the concrete covermeter survey, and dimensional verification.

j) Documentation of any defects or deficiencies as specified in the Documentation of Inspection and Repairs clause.

k) Documentation of any repairs, by standard method or accepted proposal, as specified in the Documentation of Inspection and Repairs clause. The repair proposal, for repairs by accepted proposal.

l) When steam curing is used, test results indicating the time of initial set, as specified in the Steam Curing and Other Application of Heat clause of this specification, unless standard delay periods are used.

1355.07.25.02 Prestressed Elements

In addition to the above, the precast report for prestressed elements shall include:

a) The mill certificates for the strands, along with the elongation calculations based on the actual material properties specified in the mill certificate of the strands used in the work.

b) Record of the jacking force, elongations, and corrections.

c) Test report from the manufacturer of the hold down device demonstrating that the final stress along the full length of the strand is uniform.

1355.07.26 Storage

Storage of the elements shall be as specified in the Working Drawings and the Contract Documents and shall be according to CSA A23.4.

Storage includes, but is not limited to, storage at the precast plant, storage while awaiting delivery in temporary locations or, storage at the job site.

1355.07.27 Delivery

A MTO form PH-CC-701, Request to Proceed shall be submitted to the Contract Administrator a minimum of 3 Business Days prior to delivery of each shipment of elements to the Working Area.

The elements shall not be delivered to the Working Area until the Contract Administrator has received the Manufacturer's Certificate of Conformance, the precast report, Request to Proceed, and the Contractor has received a MTO form PH-CC-702, Notice to Proceed.

Delivery shall include transportation, lifting, loading and unloading of the elements. Delivery and storage of the elements shall be according to CSA A23.4, the Working Drawings, and the Contract Documents.

Elements shall be loaded for shipping in such a manner that they can be transported and unloaded at their destination without being damaged or exposed to stresses for which they were not designed.

Elements, when stored, shall be stored in such a manner to avoid damage or excessive stress.

Advertising by means of temporary removable signing shall be permitted on elements only while in transit to the site. Any signing shall not damage the elements. Any permanent markings on a surface that would be visible after installation shall not be permitted.

1355.08 QUALITY ASSURANCE

1355.08.01 General

The acceptance of elements shall be as specified in this specification.

Acceptance of compressive strength, air void system, rapid chloride permeability and salt scaling resistance, if applicable, shall be on a lot basis.

Lots not meeting the requirement specified in the Contract Documents shall be deemed rejectable.

1355.08.02 Lot Size

The Contract Administrator shall determine the limits of each lot prior to commencing production, based on the lot size definition specified in Table 8, and shall confirm the specific elements to be included in each lot prior to commencing production of that lot.

1355.08.03 Acceptance of Compressive Strength of Concrete

1355.08.03.01 General

Testing of compressive strength of cylinders shall be according to LS-426 for concrete with silica fume and high strength concrete, and according to LS-407 for all other concrete. Three cylinders shall be tested to determine the compressive strength of the lot.

Testing of compressive strength of cores shall be according to LS-410. Three cores shall be tested to determine the compressive strength of the lot.

The 28-Day concrete compressive strength of a lot shall be considered acceptable when it meets all of the following:

a) The average of the three individual compressive strength test specimens is equal to or greater than the specified compressive strength; and

b) No individual compressive strength test specimen shall be more than 4.0 MPa below the specified compressive strength.

Unacceptable lots shall be rejected and replaced.

Test results shall be forwarded to the Contractor as they become available

1355.08.03.02 Referee Testing

Referee testing of compressive strength may only be invoked by the Contractor within 3 Business Days of receipt of the acceptance test result for compressive strength.

The referee laboratory shall be designated by the Owner based on the applicable roster and cores shall be tested according to LS-410.

Referee test results shall be forwarded to the Contractor as they become available.

The confirmation value for confirming the acceptance test result shall be the greater of 10% of the specified strength or 10% of the strength of the acceptance specimens, expressed to one decimal place.

If the difference between the referee test result and the acceptance test result is less than the confirmation value, the acceptance test result is confirmed, and the acceptance test result shall be used in the determination of acceptance of the lot. If the difference between the referee test result and the acceptance test result is greater than the confirmation value, the acceptance test result is not confirmed, and the acceptance test result shall be disregarded and the referee test result shall replace the acceptance test result in the acceptance requirements of this specification.

The cost of compressive strength referee testing shall be as specified in the Contract Documents. When the referee result confirms the acceptance test result, the Contractor shall be charged the cost of compressive strength referee testing. When the referee result does not confirm the acceptance test result, the Owner will bear the cost.

1355.08.04 Acceptance of Air Void System in Hardened Concrete

1355.08.04.01 General

For wet cast concrete, testing of air void system shall be according to LS-432. One half of a core shall be tested to determine the acceptability of the lot. The other half of the core shall be retained by the Owner for audit purposes.

Test results will be forwarded to the Contractor, as they become available.

For the lot to be considered acceptable, the sample shall have a minimum air content of 3.0% and a spacing factor of 0.200 mm or less. Acceptable lots shall be subject to full payment.

Lots with a sample having a spacing factor greater than 0.200 mm or air content less than 3.0% are unacceptable.

Unacceptable lots shall be removed and replaced except where the Owner permits the work to remain in place. The removal and replacement of unacceptable lots shall be at no additional cost to the Owner. The replacement lots shall be evaluated for acceptance on the same basis as the original lot.

Lots with samples with a spacing factor greater than 0.200 mm and less than or equal to 0.250 mm may be permitted to remain in place. When the Owner permits the work to remain in place, it shall be subject to a payment reduction.

Lots having a sample with a spacing factor more than 0.250 mm or air content less than 3.0% shall be deemed rejectable.

1355.08.04.02 Referee Testing

Referee testing of air void system parameters shall be according to OPSS 1350.

The cost of air void system referee testing shall be according to OPSS 1350

1355.08.04.03 Payment Reduction

For the purpose of calculating a payment reduction, the Contract Administrator will round-off the spacing factor test data to three decimal places according to LS-100 and will determine the quantity of concrete in the lots using the dimensions specified in the Contract Documents.

Payment for an unacceptable lot represented by the core shall be calculated according to the following:

$$\text{Payment reduction for a lot} = \text{Lot quantity} \times \text{Price} \times \left(\frac{100 - \text{P}}{100}\right)$$

Where:

Lot quantity = are calculated based on plan dimension, for MSE and slabs the unit of measure is m^2, for all other precast concrete, the unit of measure is m^3.
Price = Contract price for the tender item.
P = pay factor for the lot according to the spacing factor specified below:

Spacing Factor (mm)	Pay Factor (P)
> 0.200 and ≤ 0.220	90
> 0.220 and ≤ 0.240	80
> 0.240 and ≤ 0.250	70

1355.08.05 Acceptance of Rapid Chloride Permeability

1355.08.05.01 General

Acceptance of rapid chloride permeability shall be based on the result of the core(s) representing the lot, when tested according to LS-433 at 28-32 Days of age.

For cores that are a minimum of 120 mm in length, two 50 mm long samples shall be cut from the core representing the lot, tested, and the results averaged to determine the acceptance of the lot.

For cores that are less than 120 mm in length, one 50 mm sample shall be cut from each of the two cores representing the lot and the results averaged to determine the acceptance of the lot.

Test results shall be forwarded to the Contractor as they become available.

1355.08.05.02 Concrete Without Silica Fume

Lots with rapid chloride permeability less than or equal to 2,500 coulombs are considered acceptable. Acceptable lots shall be subject to full payment.

Lots with a rapid chloride permeability result greater than 2,500 coulombs are unacceptable. If the Owner permits the work to remain in place, lots with an average value of rapid chloride permeability exceeding 2,500 coulombs and less than or equal to 3,500 coulombs shall be subject to a payment reduction.

Lots with rapid chloride permeability results exceeding 3,500 coulombs shall be deemed rejectable.

1355.08.05.03 Concrete Containing Silica Fume

Lots with rapid chloride permeability less than or equal to 1,000 coulombs are considered acceptable. Acceptable lots shall be subject to full payment.

Lots with a rapid chloride permeability result greater than 1,000 coulombs are unacceptable. If the Owner permits the work to remain in place, lots with an average value of rapid chloride permeability exceeding 1,000 coulombs and less than or equal to 2,000 coulombs shall be subject to a payment reduction.

Lots with rapid chloride permeability results exceeding 2,000 coulombs shall be deemed rejectable.

1355.08.05.04 Referee Testing

1355.08.05.04.01 General

Referee testing of rapid chloride permeability may only be invoked by the Contractor within 3 Business Days of receipt of the acceptance test result.

For lots where a referee core is taken at the time the acceptance core is taken, referee testing shall be carried out on the reserved core representing the lot for which referee testing was invoked, and the results shall be averaged to obtain the test result for the lot.

For lots where a referee core is not taken at the time the acceptance core is taken, referee testing shall be carried out on a core taken by the Contractor within 3 Business Days of invoking referee testing. The core shall be taken by the Contractor from the same element which the acceptance core was taken from as specified in the Coring for Referee Testing clause.

The number of cores per lot and core dimensions shall be the same as specified for acceptance testing.

Referee testing shall be carried out on two-50 mm samples obtained from the core or cores representing the lot for which referee testing was invoked, and the results shall be averaged to obtain the test result for the lot.

Cores shall be tested according to LS-433.

The referee laboratory shall be designated by the Owner based on the applicable roster and cores shall be tested by that laboratory.

Referee test results will be forwarded to the Contractor as they become available.

The cost of referee testing of rapid chloride permeability for all concrete shall be according to the Referee Testing Cost clause in the Acceptance of Rapid Chloride Permeability subsection in OPSS 1350.

1355.08.05.04.02 Concrete Without Silica Fume

When the referee result is greater than the acceptance test result or no more than 500 coulombs below the acceptance test result, the acceptance test result is then confirmed and shall remain valid. When the referee test result for the lot is more than 500 coulombs below the acceptance test result, the acceptance test result is then not confirmed, and the referee test result shall be used for determining acceptability of the lot.

1355.08.05.04.03 Concrete Containing Silica Fume

When the referee result is greater than the acceptance test result or no more than 300 coulombs below the acceptance test result, the acceptance test result is then confirmed and shall remain valid. When the referee test result for the lot is more than 300 coulombs below the acceptance test result, the acceptance test result is then not confirmed, and the referee test result shall be used for determining acceptability of the lot.

1355.08.05.05 Payment Reduction

The payment reduction for concrete without silica fume shall be calculated based on individual lots and applied as follows:

$$\text{Payment reduction} = \text{Lot quantity} \times \frac{\text{C} - 2500}{3}$$

Where:

Payment reduction = payment reduction of a lot ($)
C = rapid chloride permeability of a lot (coulombs)
Lot quantity = volume of concrete in a lot (m³) (calculated based on plan dimension)

The payment reduction for concrete containing silica fume shall be calculated based on individual lots and applied as follows:

$$\text{Payment reduction} = \text{Lot quantity} \times \frac{\text{C} - 1000}{3}$$

Where:

Payment reduction = payment reduction of a lot ($)
C = rapid chloride permeability of a lot (coulombs)
Lot quantity = volume of concrete in a lot (m³) (calculated based on plan dimension)

1355.08.06 Acceptance of Salt Scaling Resistance

1355.08.06.01 General

When specified for acceptance, salt scaling resistance shall be based on the average result obtained on two sawn samples per lot, and tested according to LS-412. For a lot to be considered acceptable, the average cumulative mass loss of the two samples after 50 freeze-thaw cycles shall not exceed 0.8 kg/m².

A lot with an average cumulative mass loss greater than 0.8 kg/m² and less than or equal to 1.2 kg/m² shall be considered unacceptable. Unacceptable lots shall be rejected and replaced, except where the Owner permits an unacceptable lot to remain in place. When the Owner permits an unacceptable lot to remain in place it shall be subject to a payment reduction.

A lot with an average cumulative mass loss exceeding 1.2 kg/m² shall be rejected and replaced.

1355.08.06.02 Referee Testing

Referee testing of salt scaling resistance may only be invoked by the Contractor within 3 Business Days of receipt of the acceptance test result.

Referee testing for salt scaling resistance shall be carried out on the set of two referee sawn samples according to LS-412.

Referee test results will be forwarded to the Contractor as they become available.

When the referee result is greater than the acceptance test result or no more than 0.1 kg/m² below the acceptance test result, the acceptance test result is then confirmed and shall remain valid. When the referee test result for the lot is more than 0.1 kg/m² below the acceptance test result, the acceptance test result is then not confirmed, and the referee test result shall replace the acceptance test result in the acceptance requirements of this specification.

The cost of referee testing shall be as specified in the Contract Documents.

When the referee result confirms the acceptance test result, the Contractor shall be responsible for the cost of salt scaling resistance testing. When the referee result does not confirm the acceptance test result, the Owner shall bear the cost.

1355.08.06.03 Payment Reduction

Payment reduction for an unacceptable lot represented by the sawn samples shall be calculated and applied as follows:

$$\text{Payment reduction for a lot} = \text{Lot quantity} \times \text{Price}\left(\frac{100 - \text{P}}{100}\right)$$

Where:

Lot quantity = MSE front face area in a lot (m²) (calculated based on plan dimension), or
= Concrete barrier area of both faces of all elements in a lot (m²)
Price = Contract price for the MSE precast fabrication tender item
P = Pay factor for the lot based on the average cumulative mass loss specified below:

Average Cumulative Mass Loss, kg/m²	Pay Factor (P)
> 0.8 and ≤ 1.0	75
> 1.0 and ≤ 1.2	50

1355.08.07 Acceptance of Water, Admixtures, and Cementing Materials

Acceptance of water, admixtures, and cementing materials shall be according to OPSS 1350.

1355.08.08 Acceptance of Concrete Temperature

Elements that meet the temperature requirements of this specification during production, the curing period, and, if applicable, the cold weather protection period, shall be considered acceptable. Elements that do not meet one or more of the temperature requirements of this specification are deemed rejectable.

For girders, each girder for which the highest temperature has been maintained below 65.0°C during the moist curing, moisture retention, and protection periods and which meets all other requirements of the Contract Documents shall be eligible for a payment bonus. The bonus shall be $1,000 for each girder, up to a maximum of $10,000 in total for all of the girders in a single structure. A girder which is rejectable or fails to fully meet the requirements of the Contract Documents shall not be eligible for a bonus.

1355.08.09 Acceptance of Surface Finish

All elements meeting the surface finish requirements of this specification shall be considered acceptable. For elements that do not meet the surface finish requirements of this specification, a proposal for repair shall be submitted by the Contractor, as specified in the Defects, Deficiencies and Repairs subsection.

1355.08.10 Dimensional Verification and Concrete Cover Measurements

1355.08.10.01 Girders, Culverts and Bridge Elements

For girders, culverts and bridge elements, the Owner will carry out measurements on at least one element per lot, as defined in Table 8, to confirm compliance with the specified dimensional and concrete cover requirements.

If an element fails to meet the specified dimensional or cover tolerances:

a) It shall be deemed rejectable; and

b) A consultant will be retained by the Owner, at the Contractor's expense, to verify that all the other elements in the lot are within the specified tolerances.

1355.08.10.02 All Other Elements

For all other elements, the Owner will carry out dimensional verification and concrete cover measurements, on randomly selected elements within the lot.

A total of 30 measurements per lot will be carried out for concrete cover verification. Acceptance of concrete cover over steel reinforcement shall be based on the percentage of satisfactory measurements. When 10.0% or more of the total number of measurements per lot is outside the specified limits, the lot shall be deemed rejectable.

For dimensional verification, a total of five elements per lot will be measured. The lot shall be acceptable if the dimensions of each element are within the specified tolerances in the Dimensional Tolerances subsection.

If an element fails to meet the dimensions and concrete cover within the specified tolerances:

a) It shall be deemed rejectable; and

b) A consultant will be retained by the Owner, at the Contractor's expense, to verify that all the other elements in the lot are within the specified tolerances.

1355.08.11 Defects and Deficiencies

1355.08.11.01 Defects and Deficiencies Repairable by Standard Methods

An element having one or more of the defects and deficiencies specified in Table 4 shall be deemed unacceptable and shall be repaired according to Table 4.

1355.08.11.02 Defects and Deficiencies Causing Rejection

An element having any one or more of the following defects and deficiencies shall be rejected and replaced:

a) If concrete temperature exceeds the maximum concrete temperature specified in Table 2 during the curing period, or

b) If concrete temperature falls below 10°C during the curing period or 0°C during the cold weather protection period, or

c) If an element has honeycombing, voids, cavities, spalls, or delaminations, in the concrete that exceed the conditions specified in Table 4, or

d) If a culvert or bridge element has a crack with a width greater than 1.0 mm measured at any point on the crack. For all other elements, if the crack width is greater than 0.3 mm measured at any point on the crack, or

e) If there is a crack that extends through to the opposite face of the element. For girders, if there is a crack in the bottom flange that extends through to the opposite face, unless the entire crack is located at the end of the girder and will be fully encased in concrete, or

f) If an element contains a cold joint, or

g) If cover does not meet the specified requirements, or

h) For prestressed elements, if breakage of strand wires exceeds the limit permitted in CSA A23.4, or

i) For concrete barriers, an element having a visible fracture, distortion or perforation on the steel elements of each connecting device, or

j) For girders, if the sweep exceeds 1.5 mm/m length of girder.

1355.08.11.03 All Other Defects and Deficiencies

Any individual elements having one or more of the defects and deficiencies listed below shall be deemed unacceptable and shall be repaired:

a) An element's surfaces have not been kept in a continuously wet condition during the curing period and failure to maintain moist curing has occurred;

b) Defects or deficiencies that are not identified as rejectable or specified as repairable by standard methods in Table 4;

c) More than one of the defects or deficiencies listed in Table 4, except for bugholes, are located in the same area in the element;

d) Three occurrences of the same defect, except for bugholes, are present in the element;

e) Surface finish is unacceptable;

f) Dimensional tolerances of the element do not meet the requirements of the Contract Documents;

g) There is the presence of pour lines;

h) For prestressed elements, failure to comply with relevant requirements for stressing where applicable; or,

i) For girders, when an element has horizontal or inclined cracks in the web, where the maximum width of crack is greater than 0.2 mm but less than 0.3 mm.

Horizontal or inclined cracks in the web, where the maximum width of crack is less than 0.2 mm, shall not be considered a defect or deficiency.

A proposal for repair or remediation shall be submitted to the Contract Administrator for review as specified in the Defects, Deficiencies and Repairs subsection. The Contractor shall not proceed with repairs until approval of the proposal has been received.

1355.08.11.04 Acceptance of Repairs

Acceptance of elements shall be based on the satisfactory completion of all repairs, if applicable.

The Contract Administrator shall conduct a visual inspection and/or other measures as required, including requesting additional coring, covermeter surveys or any other testing deemed necessary to assess the effectiveness and acceptability of the repairs.

TABLE 1
Precast Plant Certification Categories

Precast Concrete Category	Plant Certification
• Bridge Elements - Non-Prestressed	**Certified by:** CSA or CPCQA **Category:** CSA A 23.4 Structural; non-prestressed: **Product Group:** Group B - Precast Bridge Products; B1
• Bridge Elements - Prestressed	**Certified by:** CSA or CPCQA **Category:** CSA A 23.4 Structural; prestressed: **Product Group:** Group B - Prestressed Miscellaneous Bridge Products or Prestressed Straight Strand Bridge Members; B2 or B3
• Concrete Barrier • MSE • Noise Barrier • Slabs	**Certified by:** CSA or CPCQA **Category:** CSA A 23.4 Structural; non-prestressed: **Product Group:** Group B - Precast Bridge Products; B1
• Culverts	**Certified by:** CSA or CPCQA **Category:** CSA A 23.4 Structural; non-prestressed: **Product Group:** Group B - Precast Bridge Products; B1
• Girders	**Certified by:** CSA or CPCQA **Category:** CSA A23.4 Structural; prestressed: **Product Group:** Group B - Prestressed Straight Strand Bridge Members or Prestressed Deflected Strand Bridge Members; B3 or B4
• All other elements	**Certified by:** CSA or CPCQA **Category:** CSA A 23.4 Structural; non-prestressed: **Product Group:** Group B - Precast Bridge Products; B1

TABLE 2
Maximum Concrete Temperature

Precast Concrete Category	Maximum Concrete Temperature
• Girders	70.0 °C
• Bridge Elements • Culverts	Maximum thickness ≤ 500 mm: 60.0 °C Maximum thickness > 500 mm: 65.0 °C
• Concrete Barrier • MSE • Noise Barrier • Slabs • All other elements	60.0 °C

TABLE 3
Concrete and Ambient Temperature Measurements

<table>
<tr><th>Precast Concrete Category</th><th>Frequency</th><th>Location of Temperature Sensors</th></tr>
<tr><td>• Culverts</td><td>Each element</td><td>• Ambient air temperature (1)
• Centrally at mid-span and mid-depth of the longest span, typically the top or bottom of the element (1).

For culverts > 3.0 m and ≤ 6.0 m:
• Internal temperature at the expected point of maximum internal temperature, typically a haunch, located centrally within the concrete, mid-depth of the culvert (1).
• Surface temperature (1).

For culverts with span > 6.0 m:
• In each half of the span, internal temperature at the expected point of maximum internal temperature, typically a haunch, located centrally within the concrete, mid-depth of the culvert (1 in each half).
• Surface temperature (2).</td></tr>
<tr><td>• Girders</td><td>Each element</td><td>• Ambient air temperature at each end of the girder within the enclosure (2)
• Surface temperature (1)

Internal temperature:
• I-Girders:
○ Centroid of bottom flange at mid-span (1), for maximum temperature
○ Middle of web, 1 m from each end (2)
• Box Girders:
○ Mid-depth at the centroid of solid section at each end (2), for maximum temperature
• Middle of bottom slab at mid-span (1)</td></tr>
<tr><td>• Bridge Elements</td><td>Each element</td><td rowspan="2">• Ambient air temperature (1)
• Internal temperature at the expected point of maximum internal temperature, located centrally within the concrete at the maximum section thickness (1).
• Surface temperature (1).</td></tr>
<tr><td>• Concrete Barrier
• MSE
• Noise Barrier
• Slabs
• All other elements</td><td>One element for each element type, of the same mix design, per Day’s production</td></tr>
<tr><td colspan="3">Notes:
A. Ambient air temperature shall be measured adjacent to the concrete.
B. Surface temperature of the element shall be measured at a depth of between 5 and 10 mm from the concrete surface and shall be corresponding to the location of the temperature sensor installed to measure maximum internal temperature. Surface temperature shall be measured at each location where the internal concrete temperature is measured.
C. Number of temperature sensor shown above in parentheses.</td></tr>
</table>

TABLE 4
Defects and Deficiencies Repairable by Standard Methods

Defect or Deficiency (Note 1 and 2)	Condition	Repair Method
Bugholes	Bugholes with depth > 5 mm and all dimensions at the surface not exceeding 25 mm. Bugholes with a depth ≤ 5 mm and any dimension at the surface greater than 50 mm and not exceeding 100 mm.	a) Within 3 Days following the removal of forms or curing materials fill bugholes meeting the conditions in this table. b) Blast surfaces with high pressure water to remove any weak or loose material. c) The holes shall be moist at the time of filling. d) Fill bugholes with a proprietary patching material placed and cured according to the manufacturer's instructions.
Honeycombing, Voids, Cavities, Spalls, and Delaminations (Note 3)	Any area less than an equivalent area of 300 mm x 300 mm with no steel reinforcement exposed. For girders, cumulative total area of this type of repair shall not exceed 10% of each face of the girder. For culverts, cumulative total area of this type of repair shall not exceed 2% of any face of the culvert.	a) Square all sides of the repair area. b) Sawcut perimeter of removal area to a depth of 10 mm or to the depth of the steel reinforcement, whichever is less. c) Remove all unsound concrete using a chipping hammer or hand tools, without damaging concrete that is to remain place, according to OPSS 928. d) Abrasive blast clean all concrete surfaces to be patched according to OPSS 929. e) Remove all dust and loose material from the prepared surface by using compressed air. f) Insert corrosion resistant wires and anchors, according to OPSS 930 and OPSS 1440. g) Moisten area to be repaired. h) Fill repair area with concrete and cure concrete according to this specification. i) An acceptable proprietary concrete patching material may be used. Proprietary patching materials shall be placed and cured according to the manufacturer's recommendations.
Cracks (Note 3)	For culverts and bridge elements: For width of crack ≥ 0.30 mm and ≤ 1.0 mm, and total linear measurement of crack per m^2 is < 2 m	Repair according to OPSS 932.
	All elements, except for girders: For width of crack < 0.30 mm	Apply a concrete sealer to the entire element, except areas against which new concrete is to be placed or areas in contact with bearings, if applicable. Where sealing of a visible element is required all elements of the component or structure shall be sealed for consistency of appearance.

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TABLE 4
Defects and Deficiencies Repairable by Standard Methods
Continued From Previous Page

Defect or Deficiency (Note 1 and 2)	**Condition**	**Repair Method**
Low Cover	Low cover readings between - 5 mm and - 0 mm of the specified cover, except girder soffits between bearing cutouts.	Apply a concrete sealer to the entire element, except areas against which new concrete is to be placed or areas in contact with bearings, if applicable. Where sealing of a visible element is required all elements of the component or structure shall be sealed for consistency of appearance.
Sweep, for girders	Sweep greater than 1.0 mm/m length but less than or equal to 1.5 mm/m length.	Push or pull the girders to within tolerance. Girders that can be brought into tolerance and maintained at that position without visible signs of distress shall be accepted. Girders greater than or equal to 1,900 mm in depth shall be pulled or pushed at both the top and bottom flange.

Notes:

1. Where two or more of the defects or deficiencies listed in Table 4, excluding bugholes, are located in the same area in the element, the element is rejectable. A repair proposal may be submitted to the Contract Administrator.
2. When three occurrences of the same defect or deficiency listed in Table 4 are present in the element, excluding bugholes, the element is rejectable. A repair proposal may be submitted to the Contract Administrator.
3. Not repairable by standard method if there is honeycombing, voids, cavities, spalls, delaminations, or cracks in the concrete within a bearing surface area of a girder, defined by the contact area of the bearing plus 30 mm on all sides, except when the bearing area of the girder is fully encased in concrete.

TABLE 5
Dimensional Tolerances for Girders

Measurement	Tolerances
Flange Depth and Web Width for Girders With Voids	Flange depth ± 10 mm Web width ± 10 mm
Flange Depth and Web Width for Girders Without Voids	Flange depth ± 5 mm Web width -5/+10 mm
Hold-Down Position Along Length	± 300 mm
Length: Straight-line measurement taken horizontally at the mid-height of girder	± 1.0 mm/m; not to exceed ± 25 mm
Overall Depth	± 8 mm for depths up to 600 mm ± 12 mm for depths over 600 mm
Squareness and Plumbness	1 in 200 maximum
Stirrup Projection	-10/+15 mm
Sweep: • I-girders, spaced box girders, and spaced hollow slab girders • Abutting box and hollow slab girders	1 mm/m length of girder. ± 10 mm
Void and Diaphragm Position Along Length	± 25 mm
Width: Flanges and Box Girders	± 10 mm

TABLE 6
Dimensional Tolerances for Culverts

Measurement	Tolerances
Span: Straight-line measurement taken horizontally at the mid-height of element perpendicular to the centre line of the culvert.	± 15 mm from design drawings
Height	± 15 mm from design drawings
Length	+ 15 / - 5 mm
Wall and Slab Thickness	+ 10 mm, - 5 mm
Haunch	± 10 mm
End Squareness or Skew (Note 1)	< 15 mm along its length
Location of Blockouts	± 15 mm
Location of Inserts	± 10 mm
Notes: 1. Variations in the lengths of two opposite surfaces of the element. The ends of the element shall be normal to the wall and centreline of the element within the tolerances specified elsewhere in this table except where special culvert elements, e.g. end walls, toe walls, etc. are specified.	

TABLE 7
Fabrication Dimensional Tolerances for Bridge Elements

Measurement	Tolerances
Length (Note 1): Straight-line measurement taken horizontally at the mid-height of element in the longitudinal direction	± 5 mm
Width (Note 1): Straight-line measurement taken horizontally at the mid-height of element in the transverse direction	± 5 mm
Nominal Depth: Straight-line measurement taken vertically at the mid-length of element	± 5 mm
Variation from Specified Plan End Squareness or Skew	± 10 mm
Stirrup Projection from Surface (Note 3, 4)	± 15 mm
Shear Key Depth (Note 4)	± 5 mm
Shear Key Width (Note 4)	± 5 mm
Location of Blockout (Note 4)	± 25 mm
Size of Blockout (Note 4)	± 25 mm
Location of Inserts (Note 4,5)	± 25 mm

Notes:
1. Overall length and width of assembled units, side by side shall have a combined tolerance of ± 25 mm.
2. For Partial Depth Precast Deck Panels use ± 6 mm.
3. For Partial Depth Precast Deck Panels use ± 10 mm.
4. Not all elements contain the described feature.
5. For Partial Depth Precast Deck Panels use ± 13 mm.

TABLE 8
Lot Size and Sampling for Acceptance Testing, Cover and Dimensional Verification

Precast Concrete Category	**Lot Size** (Note 1)	**Sample Type and Size** (Note 6)	**Number of Samples per Lot**
Girders	All girders of the same girder type produced over 7 consecutive Days; or, if more than 4 girders are produced in 7 consecutive Days, a lot means every 4 girders produced consecutively (Note 2).	Cylinders 100 mm diameter and 200 mm long	• 3 cylinders for 28-Day compressive strength
		Cores 100 mm diameter 220 mm long or full depth, whichever is less	One set of 2 cores: • 1 for AVS • 1 for RCP
Culverts	All elements of the same element type produced over 7 consecutive Days (Note 3).	Cores 100 mm diameter 220 mm long or full depth, whichever is less	One set of 5 cores: • 3 for 28-Day compressive strength • 1 for AVS • 1 for RCP
Bridge Elements	All elements of the same element type produced over 7 consecutive Days (Note 3).	Cores 100 mm diameter and 200 mm long.	For elements greater than or equal to 200 mm thick, one set of 5 cores: • 3 for 28-Day compressive strength • 1 for AVS • 1 for RCP
		Cores for Strength The full depth of the element shall be cored such that the core has a length to diameter ratio of at least 1.5, but shall not be less than 75 mm in diameter Core for AVS 150 mm diameter, maximum 50 mm long Cores for RCP 100 mm diameter, 70 mm long	For elements less than 200 mm but greater than or equal to 120 mm thick, one set of 6 cores: • 3 for 28-Day compressive strength • 1 for AVS • 2 for RCP (both used for acceptance testing)
		Cylinders 100 mm diameter and 200 mm long Core for AVS 150 mm diameter, maximum 50 mm long Cores for RCP 100 mm diameter, 70 mm long	For elements less than 120 mm thick: • 3 cylinders for 28-Day compressive strength • 1 core for AVS • 2 cores for RCP (both used for acceptance testing)

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TABLE 8
Lot Size and Sampling for Acceptance Testing, Cover and Dimensional Verification
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Precast Concrete Category	**Lot Size** (Note 1)	**Sample Type and Size** (Note 6)	**Number of Samples per Lot**
MSE	All elements from one structure. The maximum lot size shall be 500 m² of vertical face of the MSE.	Cores 100 mm diameter and 200 mm long. Sawn Samples 300 mm x 300 mm (Note 4)	One set of 6 cores: • 3 for 28-Day compressive strength • 1 for AVS (wet cast only) • 2 for RCP (1 for QA and 1 for referee) Two sets of 2 sawn samples for salt scaling resistance (1 for QA and 1 for referee).
Concrete Barrier	The lesser of either all elements produced over 7 consecutive Days or 125 elements consecutively produced.	Cores 100 mm diameter and 200 mm long Sawn Samples 300 mm x 300 mm (Note 4)	One set of 5 cores: • 3 for 28-Day compressive strength • 1 for AVS • 1 for RCP Two sets of 2 sawn samples for salt scaling resistance (1 for QA and 1 for referee).
Slabs	All elements produced over 7 consecutive Days.	Cores 100 mm in diameter and full depth	One set of 5 cores: • 3 for 28-Day compressive strength • 1 for AVS • 1 for RCP.
Noise Barrier (Note 5)	1,000 lineal meters of noise barrier produced consecutively.	Cores 100 mm diameter and 200 mm long or full depth of the element	
Appurtenances	All elements produced over 7 consecutive Days.	Cores 100 mm diameter and 200 mm long or full depth of the element	
All other elements	All elements produced over 7 consecutive Days.	Cores 100 mm in diameter and full depth	

Notes:

1. Elements of the same lot shall be:
   - manufactured by a single supplier,
   - manufactured at the same precast plant,
   - made from the same concrete mix design, and
   - for a single ministry Contract.

   At the discretion of the Owner, and prior to commencing production, the lot sizes may be modified.
2. For Contracts requiring high-volume production, the use of a larger lot size may be proposed, up to a maximum of 20 girders per lot produced over no more than 7 consecutive Days, and shall be subject to the approval of the Owner. The established lot size shall remain consistent for the duration of the Contract.
3. At the discretion of the Owner, and prior to commencing production, elements of different types or sizes may be combined in one lot.
4. Dimensions shall be within -5/+10 mm of specified values. Sawn samples shall be trimmed to a thickness of 75 mm to 100 mm.
5. Bottom panels and upper reflective panels, when used, shall be sampled as separate lots.
6. The Contract Administrator may direct the Contractor to obtain cores with different dimensions for certain components.

TABLE 9
Location of Coring within the Element

Precast Concrete Category	Location of Coring
• I-girders	Cores shall be from the middle quarter of the girder length, in the upper half of the web, outside of the flange area.
• Box Girders	Cores shall be removed at random locations of the top slab.
• Culverts	Cores shall be removed from the sides or haunch of the elements.
• Bridge Elements • MSE • Concrete Barrier • Slabs • Noise Barrier • Appurtenances • All other elements	Random location in the element, as directed by the Contract Administrator.